WORSTED, and WORSTED *Manufacture.* The term worſted is applied to yarn, and manufactured goods made of combed wool. Worſted is properly a branch of the *Woollen Manufacture*, to which article we refer our readers; but the latter term, ſtrictly ſpeaking, is applied only to yarn, or pieces made entirely or in part of carded wool. The characteriſtic diſtinction between combing-wool and ſhort or clothing-wool has been already ſtated under the article WOOL. (See WOOL and WOOLLEN *Manufacture.*) Worſted goods were made in England as early as the time of Edward II. In the account of exports in the following reign, already given in the article WOOLLEN *Manufacture*, the number of pieces of worſted goods exported is nearly double that of woollen cloths. According to Camden, the name is derived from Worſted, a town in Norfolk, where worſted ſtuffs were firſt made. According to Dr. Parry, in his "Eſſay on the Merino Breed of Sheep," worſteds were called by the Flemings '*Oſtades*,' and as the manufacture was in their hands long before it was introduced into England, it is probable that our appellation is a corruption of their's. Oſtade was long ago a common ſurname in Flanders, and was perhaps that of ſome perſon famous for this particular branch of the woollen trade, which afterwards was appropriated to an eſtabliſhment of ſimilar manufacturers in Norfolk.

Worſted yarn is made of long or combing-wool, in which the fibres are all laid even parallel with each other by the wool-comb. It may be claſſed into two great diviſions, the ſoft and the hard worſted yarn. The ſoft yarn is made of the ſhorter kinds of combing-wool, the ſorting of which has been already deſcribed under the article WOOL. The ſhort and long combing-wools are both prepared for ſpinning by the comb in the ſame manner, except that for ſome kinds of fine hard yarn made from the latter, the wool is combed, and afterwards ſpun nearly without oil. This is the caſe with the yarn for bombazines. The ſoft yarn for hoſiery receives but little twiſt in the ſpinning, and two, three, or more threads are afterwards twined together on what is called a doubling-mill, to make a thread of requiſite ſtrength and thickneſs to be woven on the ſtocking-frame. See STOCKING-*Frame.*

Knitting-

Knitting-yarn is twined much harder than yarn for the frame. For mixed coloured ſtockings, part of the wool is dyed and mixed with the white in the proceſs of combing. The principal ſeats of the worſted hoſiery manufacture in England were Nottingham and Leiceſter; but of late years the worſted hoſiery has declined at the former place, the trade there being principally confined to ſilk and cotton articles. Formerly hoſiery compriſed a variety of worſted articles, particularly caps, which were generally worn in England before the introduction of hats.

At Aberdeen, in Scotland, there is a conſiderable manufacture of hoſiery, the wool being principally ſupplied from London. Worſted ſtockings, and lamb's-wool hoſiery, to the amount of from fifty to ſeventy thouſand pounds, are ſaid to have been annually exported from Aberdeen to Holland. Of the number of hands employed in worſted hoſiery in England, or the annual value of the goods made, we have no correct account. Perhaps ſome eſtimate may be formed from the amount of exports of woollen hoſiery given under the head *Woollen Manufacture*, in the table of exports, in which it will be ſeen, that in the year 1816 the worſted hoſiery exported amounted to one hundred and fifty-one thouſand and ſixty pounds. This, we believe, includes the hoſiery made of woollen yarn, or what is generally called lamb's-wool yarn, an article which, ſince the beginning of the preſent century, has been greatly increaſing in demand. Soft worſted yarn for hoſiery, during the laſt twenty years, has been principally ſpun and doubled by machines in large worſted-mills. Previouſly to that time, worſted-making by hand-ſpinning was a diſtinct trade from hoſiery. The worſted-maker bought his different ſorts of combing-wool from the wool-ſtapler, combed and ſpun it, and ſold the yarn to the hoſier. Since then, the hoſiers have been principally ſupplied with worſted yarn from large mills eſtabliſhed in Leiceſterſhire, Nottinghamſhire, and Warwickſhire. Of late, however, many of the hoſiers are manufacturing their own yarn on machines or mules turned by the hand, or in ſmall mills turned by horſes or water.

The combing-wools of Kent are better ſuited for hoſiery worſted yarn than any other in England, particularly for machine-ſpinning. This excellence is derived partly from the ſoftneſs as well as ſoundneſs of the wool; but particularly from the ſtaple being nearly of one uniform thickneſs from the bottom to the top. See Wool.

Picardy and Normandy were the principal ſeats of the worſted hoſiery in France. Under the article Woollen *Manufacture*, it will be ſeen that 1,250,000 pounds weight of wool were conſumed annually in the manufacture of hoſiery in Picardy before the French revolution.

The ſtocking-frame was invented by William Lee, M.A. of Cambridge, in 1589, and was afterwards introduced into France. This invention took place in England only 28 years after the knitting of hoſiery yarn on needles had been introduced from Spain. See Stocking-*Frame*.

Hard worſted yarn for worſted ſtuffs or pieces is ſpun much ſmaller, and twiſted much harder, than the ſoft worſted yarn for hoſiery. In all the ſtouter kinds of worſted goods, the long or heavy combing-wool is uſed. (See Wool.) Under the article Woollen *Manufacture* we have noticed the introduction of the worſted trade into England, and various places where it was firſt eſtabliſhed. Norwich and ſome of the towns in Norfolk and Suffolk appear to have been the firſt where any conſiderable quantity of worſted pieces or ſtuffs were made. The names which the different kinds of worſted pieces have received are very numerous, being often derived from the manufacturer who introduced a ſlight change either in the mode of weaving or finiſhing the goods. Theſe names ſoon became obſolete, being ſupplanted by other kinds of worſted goods, ſo that we do not know at preſent to what particular kind of pieces ſome of them were formerly applied; the eſſential difference conſiſting in their being woven plain, twilled, or figured, or made with a warp of ſingle or doubled yarn, and woven ſtouter or more ſlightly, or of greater or leſs width, and whether they were glazed or not in the finiſhing.

The moſt important diſtinction between worſted pieces and woollen cloth conſiſts in the former not being milled or raiſed, ſo as to cover the ſurface with a pile, but the thread is left bare. To take off the looſe hairs which riſe from the ſurface, the worſted pieces are paſſed over a red-hot cylinder, in the ſame manner as many kinds of cotton (ſee Cotton *Manufacture*): this proceſs is called *ſinging*. For ſome particular purpoſes, a ſlight degree of milling has recently been attempted to be given to worſted pieces in the fulling-mill. The glazing communicated to ſome kinds of worſted goods is given by preſſing them between ſheets of ſtiff glazed preſs-paper and heated iron plates, which are compreſſed in a ſtrong preſſing-frame. For the weaving of figured pieces, ſee Weaving, and Draught *of Looms*.

Some kinds of very fine worſted goods are made with a warp of mohair or ſilk, as ſilk camlets and bombazines. The latter goods, with a ſilk warp and wefted with hard worſted yarn of the fineſt kind, are manufactured at Norwich. The term bombazine appears to be derived from bombycina, a kind of ſilk dreſs uſed by the Romans, and ſaid to come from Aſſyria. It is generally underſtood to have been made from the threads of an inſect called the bombyx. Bombycina is ſometimes confounded by commentators with byſſinum and ſericum. Byſſinum appears to have been a very fine kind of linen or lace; ſericum unqueſtionably means ſilken ſtuff, ſo called from the Seres, the nation whence it was procured. Probably bombycina was a coarſer kind of ſilk. In the middle ages, the word bombycina was applied to cotton. Macpherſon's Annals of Commerce. See Byssus.

Bombazines are woven with a twill, and have, as before ſtated, a warp of ſilk and a weft of fine worſted yarn. The Dutch refugees, who fled from the perſecution of the duke of Alva, introduced the manufacture of this article into Norwich in the year 1675, when the Dutch elders, according to Blomefield, preſented bombazines in court at Norwich. (Blomefield's Hiſt. of Norfolk, vol. ii. p. 205.) Worſted goods were made in Norwich as early as the reign of Edward II. This appears from a patent granted to John Peacock, for the meaſuring every piece of worſted made in the city of Norwich or county of Norfolk. Norwich has continued from that time one of the principal ſeats of the worſted and ſtuff trade. The ſale of ſtuffs made in Norwich only, in the reign of Henry VIII., amounted to 100,000*l.* annually, beſides worſted ſtockings, which were computed at 60,000*l.*

Norwich is at this day the only part of England where any conſiderable number of the very fineſt ſtuffs and bombazines are made. The manufacture of the coarſer kinds of worſteds, except camlets, has been transferred in a great meaſure into Yorkſhire. The period preceding the American revolution, from the year 1743 to 1763, may perhaps be regarded as the moſt flouriſhing era of the worſted manufactures of Norwich. According to the account of Arthur Young in 1771, the manufactures of this place had increaſed four-fold in the preceding 70 years. The number of looms was then eſtimated at 12,000, and each loom was ſuppoſed to employ ſix perſons in preparing and finiſhing

the material; and the total annual value of the goods was eſtimated at above 1,200,000*l.* Of theſe goods the eſtimate then was,

	£
The export to Rotterdam - -	480,000
——— to London - -	550,000
——— to various places - -	200,000
Total value -	1,230,000

The number of perſons employed being from ſeventy to eighty thouſand.

Since the time to which Arthur Young refers, the manufacturers of Norwich have engaged extenſively in the trade of ſilk ſhawls and other articles, in which no worſted whatever is uſed. Still, however, the worſted manufactures of Norwich may be conſidered as in a flouriſhing ſtate. The number of looms employed in worſted at the preſent time (1818) may be eſtimated at 10,000; half of which weave camlets, calimancoes, and other ſtuffs; and the other half bombazines, narrow and broad. The former are chiefly for home conſumption, the latter for the Spaniſh market. The Eaſt India company take a conſiderable quantity of the fine camlets manufactured at Norwich.

By far the greateſt part of the worſted yarn employed at Norwich is ſupplied by machine-ſpinning, from the worſted-mills in Yorkſhire, Lancaſhire, and Durham. But ſome yarn ſtill continues to be ſpun in the old manner, by the running-wheel, in Suffolk, Eſſex, Hertfordſhire, and Cambridgeſhire. In Norfolk alone, the uſe of the diſtaff ſtill remains. This inſtrument is the moſt ancient of which we have any notice, either in ſacred hiſtory, or the fabulous traditions of Grecian mythology handed down to us by Homer and Heſiod. It is at preſent vulgarly called the rock. In uſing it, the thread is drawn out from the end of the ſliver of combed wool. The motion is communicated to a rough kind of ſpindle, by twirling it between the right-hand and the thigh, which is ſuffered to continue revolving when ſuſpended by the thread, which the ſpinſtreſs gradually lengthens with her fingers.

In wheel-ſpinning, a ſmall portion of the combed wool or ſliver is laid acroſs the finger, from the centre of which, called the twitch, the thread is drawn out. About thirty years ſince, the counties of Norfolk, Suffolk, Hertfordſhire, and Eſſex, not only ſupplied all the yarn that was wanting for the manufactures of thoſe diſtricts, but ſent large quantities of worſted yarn to Halifax and Mancheſter. At preſent the trade is completely turned, and, as we have before ſtated, the greater part of the yarn uſed at Norwich is ſent there from the northern counties of England. This change has occaſioned great diſtreſs in the villages where the yarn was formerly ſpun, by depriving the wives and children of the cottagers of their common employment.

Until the middle of the laſt century, worſted goods were manufactured in conſiderable quantities in Warwickſhire, Oxfordſhire, and Northamptonſhire; but about that time the extenſion of the worſted trade in the Weſt Riding of Yorkſhire, particularly at Halifax, Bradford, and Wakefield, gradually drew this trade in a great meaſure away from thoſe counties. The manufacturers in Yorkſhire, or rather the merchants who bought the worſted pieces from the manufacturers, were, however, long unacquainted with the beſt modes of dyeing and dreſſing them; they were therefore ſent to London or Coventry to be finiſhed, but afterwards they were finiſhed in Yorkſhire. The demand to Spain, Portugal, Italy, and the Levant, took off the greater part of the worſted goods manufactured at Halifax; thoſe manufactured round Wakefield and Bradford, conſiſting chiefly of tammies and ſhalloons, were conſumed principally by England and her colonies. The Piece-hall at Halifax was firſt opened about the year 1780; and the intervening time, from thence to the year 1792, or the breaking out of the French war, may be regarded as the moſt flouriſhing era of the worſted trade in Yorkſhire. Though the cheapneſs of calicoes, as an article of female dreſs, ſince the improvements in the cotton manufacture, materially abridged the ſale for ſome kinds of worſted goods in England, this was more than compenſated by the increaſed demand for carpets with worſted warps, and other articles of luxury, in which worſted yarn was employed.

The demand in foreign markets, from the year 1782 to 1792, for Engliſh worſted goods, greatly exceeded that of any former period; but after the breaking out of the French war, the worſted trade at Halifax began to decline. The greater part of the foreign markets being cloſed againſt us, moſt of the mercantile houſes engaged in the export of worſted pieces were in conſequence ruined or declined: the trade altogether, and many of the ſmall manufacturers, engaging in the cotton trade. The introduction of Engliſh calicoes into Turkey and other parts tended alſo to leſſen the regular demand for ſhalloons and other worſted goods, as articles of female dreſs, in thoſe countries. Soon after the breaking out of the French war in 1792, the ſpinning of worſted by machinery was eſtabliſhed at Bradford and the vicinity; and continuing to increaſe, drew round that place the manufacturers of worſted goods on the decline of the Halifax trade. Bradford is now become the principal ſeat of the worſted manufacture in Yorkſhire; and ſome of the proprietors of the worſted mills, beſides ſupplying the ſmaller manufacturers with yarn, employ a very great number of looms themſelves, and carry on this branch of trade on a ſcale of extent never before known in the worſted manufacture. Within the laſt two years, the worſted trade has alſo greatly revived at Halifax.

The following are the kinds of worſted pieces at preſent principally made in Yorkſhire.

Bombazets are woven both plain and twilled, with the warp of ſingle thread; they were preſſed, and finiſhed without glazing: the width 22 inches, length 29 yards.

Tammies, or *durants*, with ſingle warps twilled, and generally coarſer than twilled bombazets: width from 32 to 36 inches, length 29 yards.

Shalloons are woven with a twill, and have a warp of ſingle thread. We believe the name was derived from Châlons in France. The pieces are from 32 to 36 inches wide, and 29 yards long.

Cubicas are very fine ſhalloons ſo called.

Sayes, or *anaſcottes*, are twilled and made with ſingle warps; they are of two kinds, one running 27 inches wide and 30 yards in length, the other 42 inches in width and 44 yards in length.

Moreens are woven plain and watered or emboſſed, and are made very ſtout, being principally uſed for furniture: their width is 28 inches, length 24 yards.

Calimancoes are woven plain and ſtriped: width 17 inches, length 29 yards.

Camlets are both plain and twilled: width 18 inches, length 29 yards. They are ſhorter than bombazets, but not many are made in Yorkſhire with doubled warps.

Laſtings have doubled warps, ſometimes of two and ſometimes of three threads, and are made with great variety of patterns, either plain, twilled, or flowered, and are diſtinguiſhed by different names, according to their figures and quality;

quality; as prunelle, amens, (probably from Amiens in France, where they were manufactured,) and drawboys: the width 18 inches, length 30 yards.

Worſted ſhag, or velvet woven like corduroi and cut, is made principally at Banbury, in Oxfordſhire, and at Coventry; but has been manufactured alſo in Yorkſhire.

In the worſted manufactures of France, there were greater varieties of pieces than in England. One kind of camlet, made with a fine warp from the wool of the Angora goat and a weft of fine worſted, was remarkably beautiful; but we believe it has not been manufactured in Yorkſhire or at Norwich.

For ſome account of the worſted manufactures of France, ſee WOOLLEN *Manufacture;* under which article we have given the hiſtory of the worſted manufacture as connected with the woollen, and where may be ſeen the number and value of the worſted pieces exported from England in the year ending January 1817. See alſo *long combing-wool*, under the article WOOL.

WORSTED *Spinning*. In the article WOOL we have given an account of the different kinds of long wool which are proper for ſpinning into worſted, alſo the manner of ſorting and ſcouring them. This wool muſt be prepared for ſpinning by repeated combings, with a comb or heckle that is provided with a great number of long ſteel pins which are ſharp-pointed. Theſe points being few in number compared with the teeth of cards, they can be ſafely introduced between and drawn through the long fibres of the wool, in order to ſeparate and ſtraighten them, without materially breaking them. Another object of the combing is, to ſeparate the ſhort fibres which are intermixed with the long ones; for in ſpinning any kind of thread, it is deſirable that the fibres ſhould be all as nearly as poſſible of a length.

Wool-combing.—In the ordinary proceſs of wool-combing by hand, the implements uſed are, 1. Two combs for each workman. 2. A poſt, to which either of the combs can be fixed, to ſupport them during the operation. 3. A comb-pot, which is a ſmall ſtove to heat the teeth of the combs, which is found to facilitate the combing. The combs are ſhewn at *fig.* 1. *Plate* I. *Woollen Manufacture:* each comb is compoſed of two rows of pointed ſteel teeth, *a* and *b*, diſpoſed in two parallel planes. One of the rows contains longer teeth than the other. They are fixed into a wooden ſtock or head *c*, which is covered with horn, and has a handle *d* fixed into it, perpendicular to the planes of the rows of teeth. The rows of teeth are about ſeven inches long, and each row contains about twenty-four teeth. The length of the longeſt teeth is near twelve inches, and the ſhorter ones about eight inches. The teeth are made of ſteel, of a round figure, and regularly tapering from the baſe, where they are fixed into the ſtock, to the point, which is quite ſharp. The teeth are about one-ſixth of an inch in diameter at the baſe; and the interval between the two adjacent teeth at the baſe is rather leſs than their diameter, or one-eighth of an inch. The ſpace between the two planes in which the teeth are diſpoſed is about one-third of an inch at the baſes of the teeth. The teeth ſhould be ſtraight and well-tempered, and poliſhed. If they become crooked in working, the workman muſt ſtraighten them, and ſet them all in a true line. The combs uſed for the laſt combing of the wool have three rows of teeth.

In the wool-comber's ſhop a poſt is fixed, as ſhewn by *fig.* 2, in order to ſupport the combs occaſionally during the working. An iron ſtem *g* is fixed faſt into the poſt, and projects horizontally from it; the extreme end of it turns upwards with a point, which is inſerted into a hole through the middle of the handle of the comb. Alſo at the other end of the ſtem *g*, cloſe to the poſt, there is a ſmall hook *h* rivetted, which terminates with a pointed pin, ſituated in an horizontal direction. This point is inſerted into a hole made in the end of the handle of the comb, in the direction of its length. The end of the comb-handle being firſt placed on the point of the hook *h*, it is let down upon the other point *g*, which, by paſſing through the handle, fixes the comb quite faſt to the poſt, as ſhewn at *fig.* 2.

In the operation of combing wool, it is neceſſary to heat the teeth of the combs, in order to ſoften and relax the fibres of the wool, and render them more eaſy to work. The heat alſo tends to diſtribute the oil with which the wool is lubricated. The combs are heated in a comb-pot or ſtove, *fig.* 3, which is a ſmall furnace built in brick, to incloſe a fire-place, of which A is the door, B the aſh-pit, and C the flue. Above the fire a circular caſt-iron plate *a a* is placed. This is made flat, except in the central part, where there is a concavity, to obtain a better action of the fire. Immediately over the plate *a*, another plate, *b b*, is placed parallel to the former, but with a ſufficient ſpace between them to admit the teeth of the combs: ſeveral pieces of iron are placed between the two plates, to keep them at a proper diſtance aſunder, and to divide the ſpace into ſmall cells proper for the combs.

In uſing this ſtove, the workman muſt be careful not to heat it too much, and a damper in the flue is very uſeful to regulate the draught; if the heat is too great, it ſpoils the temper of the comb-teeth, and injures the wool alſo. The moſt improved ſtove is heated by ſteam, which will give a ſufficient warmth, but cannot overheat the combs.

In order to comb the wool, it is ſeparated into handfuls, each containing near four ounces of wool, which is about a proper quantity to be combed at once. Theſe handfuls are ſprinkled with oil, and the wool is rolled in the hands to diſtribute it equally. The quantity of oil varies from $\frac{1}{20}$th to $\frac{1}{16}$th of the quantity of wool by weight. The comb is firſt heated by introducing the teeth into the ſtove, in one of the cells between the two iron plates; when it has acquired ſufficient heat it is withdrawn, and another comb is put in its place. The heated comb is then faſtened to the poſt, with its teeth pointing upwards, in order to be filled with wool; the comber takes one-half of the handful of wool in his hand, and catches it upon the teeth of the comb by throwing the wool over the points, ſo that they penetrate it; then by drawing the wool towards him, and at the ſame time downwards to the bottom of the teeth, a portion of the wool will remain in the teeth. The lock of wool is again caſt upon the teeth, and drawn through them, and every time ſome wool remains; this is repeated as often as is neceſſary, until all the wool is gathered upon the teeth. The comb thus filled is placed with its points in the ſtove, and the wool which is upon it remains outſide of the ſtove, but will become ſlightly warmed. The other comb, which was heating whilſt the firſt was filling, is now filled in turn, in the ſame manner as the firſt, and is then put to heat with the wool upon it, and whilſt this is going on, the workman occupies himſelf in making a handful ready for the next combing.

When both combs are properly warmed, the comber holds one of them with his left-hand over his knee, as he is ſeated on a low ſtool, and with the other comb held in his right-hand he combs the wool upon the firſt, by introducing the points of the teeth of one comb into the wool contained in the other, and drawing them through it; this is repeated for 14 or 15 ſtrokes, until the fibres of the wool are ſeparated, diſentangled, and laid parallel. In combing, he di-

rects

rects the combs ſometimes with the teeth of one parallel to the teeth of the other, and ſometimes with the teeth of the two combs at right angles, or in a croſs direction; but in all caſes he muſt take care to begin gradually, by introducing the points of the teeth, firſt into the extremity of the wool which is contained in the teeth of the comb, and then penetrating deeper into the wool at every ſucceeding ſtroke, till at laſt he works the combs as near as he poſſibly can without actually bringing their teeth in contact: without this precaution, he could not draw the comb through the wool without breaking the fibres, and tearing the wool out of the teeth of the comb; but if he proceeds cautiouſly, the wool will be diſentangled, ſeparated, and ſtraightened.

During the working, he frequently changes the combs, ſo as to work the wool upon both combs; but as the wool will gradually accumulate upon that comb which is moſt worked, he manages them ſo that at the end of about 35 or 40 ſtrokes nearly all the wool will be gathered upon one of the combs, and will hang from its teeth in a fair lock of ſtraight and regular wool. This comb he puts to heat for a moment, then fixes it to the poſt, and proceeds to draw off the wool from the comb in a ſliver. To do this, he takes hold of the wool which projects from the teeth with the fingers and thumbs of both hands, and draws it away from the teeth of the comb in a direction perpendicular to their length, without ſliding it off their points: as the wool comes away, he takes freſh hold, always ſeizing the wool at a given diſtance from the teeth. A portion of the wool which conſiſts of ſhort fibres will not come off, becauſe it does not reach to the place where the comber graſps the wool; it therefore remains in the teeth of the comb, and is drawn off afterwards. This ſhort wool, which is called noil, is unfit for worſted ſpinning; it is compoſed in part of the ſhort fibres which are naturally intermixed in the long ones, and alſo of the fragments of long fibres which are broken in the proceſs of combing. The quantity of the noil depends upon the kind of wool, and alſo on the care with which the comber has conducted his proceſs; but it will ſeldom exceed $\frac{1}{4}$th or $\frac{1}{3}$th of the quantity of the raw wool by weight.

The wool which is drawn off from the comb forms a continued ſliver or band, the fibres of which are ſtraight and parallel, but not ſufficiently ſo for ſpinning; it is therefore combed over again, and frequently it is repeated a third time. The firſt combing is called hacking, and the ſlivers produced by it are extended five together upon a table; then holding them down with one hand, they are broken again into handfuls by drawing them with the other. Theſe are combed again in the manner before deſcribed, but the heat given to the combs is much leſs. The ultimate ſliver, which is drawn off from the comb the laſt time, ſhould be very even, and compoſed of long and parallel fibres. On examining it againſt the light, every part ſhould appear equally denſe, without any entanglements of the fibres, for on theſe particulars the perfection of the ſpinning will in a great meaſure depend.

The combed wool produced from ſixteen pounds of wool uſually weighs eleven or eleven and a half pounds, for about two pounds are loſt in waſhing, and the reſt in noil and waſte in the combing. When the combing is finiſhed, the ſlivers are formed into ſix parcels, each containing ten or eleven ſlivers, which are rolled up together into a ball, and ticketed with their weight and quality, the wool-comber's mark, and wool-ſtapler's mark. In this ſtate, combed wool is called tops or Jerſey, and is ſold to the ſpinners in the country, and in cottages, who ſpin it into worſted-thread by the ſimple hand ſpinning-wheel; but the manufacturers who ſpin by machinery have wool-combers at their mills, and they uſually employ combing-machines in addition.

Combing-Machines.—The firſt combing-machine was invented by the Rev. Edmund Cartwright. His firſt two patents were in 1790, and he had another in 1792; but the machine was not rendered perfect, or brought into extenſive uſe, till a later period: and in 1802 he obtained an act of parliament to renew or extend the term of his patent. The ſpecification which he enrolled in conſequence contains drawings and deſcriptions of machines nearly of the ſame kind as thoſe which are now in uſe at many of the great worſted-mills, and which we ſhall deſcribe. Mr. Cartwright propoſed to form the raw wool into continued ſlivers, by joining the pieces of wool together, and ſlightly twiſting them, and in this ſtate they could be preſented to the combing-machine; but as this plan was not found to ſucceed, it was found neceſſary to comb the wool firſt by hand, in order to reduce it to ſlivers. This is ſtill the common practice, and takes away great part of the advantage of the machine; but we have ſeen a preparing-machine for this purpoſe, which operated very well upon the raw wool. The inventor's name we have not learned; but the rudiments of it are to be found in Mr. Cartwright's ſpecification of 1790.

Preparing-Machine.—The raw wool is ſpread upon a horizontal feeding-cloth, which is extended over two rollers, and circulates upon them: by its motion, the wool is carried forwards, and preſented to a pair of fluted rollers, which draw it in. This feeding-cloth is ſituated at the top of the machine, at the height of about five feet from the floor, ſo as to allow room for the reſt of the machinery beneath it. A principal part of the machinery is carried by a horizontal wheel of five feet diameter, which is mounted upon a vertical axis, and is turned rapidly round by the mill. This wheel carries four porcupines, which are ſmall cylindrical rollers, armed with ſpikes or teeth rather hooked. The rollers are ſituated horizontally in the plane of the wheel, with their length nearly in the direction of radii. They are about ſeven inches in diameter, and fourteen inches long, and are fixed upon horizontal ſpindles, which proceed from the circumference of the great wheel nearly to its centre, one extremity of each ſpindle being ſuſtained by the rim of the wheel, and the other in a ſupport fixed to the perpendicular axis. The porcupines are fixed on the ends of the ſpindles, near the circumference of the wheel; and on the oppoſite end of each ſpindle is a ſmall cog-wheel, to work in a worm or endleſs ſcrew, which is fixed concentric with the axis, being cut on the outſide of a hollow tube, through which the vertical axis paſſes.

By this means, the four porcupines which the wheel contains have a two-fold motion, *viz.* they are all carried round in a circle by the motion of the wheel, and at the ſame time each one has a ſlow rotative motion on its own axis, in conſequence of the cog-wheels, which work in the threads of the fixed worm.

The feeding-cloth is ſo ſituated, that the four porcupines in the great wheel will paſs in ſucceſſion exactly beneath the fluted rollers, which take the wool from the feeding-cloth; and the teeth of the four porcupines being ſharp-pointed, and rather bent forwards at the points, they penetrate and catch the wool as it comes through theſe fluted rollers, and hangs down from them. A portion of wool is thus carried away by each porcupine every time it paſſes beneath the fluted rollers; but by the ſlow revolving motion of the porcupines on their own axes, each one preſents a different row of teeth every time, and thus by degrees they become clothed with the wool which they take up.

This wool they deliver to a larger porcupine, which is placed beneath the revolving-wheel, or on the oppoſite ſide to the feeding-cloth. This porcupine is a cylinder nineteen inches diameter, and fourteen inches long: its axis is placed horizontally, and directed nearly to the centre of the vertical axis; ſo that the ſmall porcupines will be parallel to the large one when they paſs over it. The great porcupine is furniſhed with rows of teeth exactly ſimilar to thoſe of the ſmall ones, which teeth are not very numerous, but large and ſharp-pointed, and rather hooked, with the points forwards. When the ſmall porcupines paſs over the large one, there is ſo little clear ſpace between their teeth, that the wool which is contained in the teeth of the ſmall ones will be taken off by the large one, and remain in its teeth. The reaſon of this is, that the teeth of the large porcupine preſent themſelves to the teeth of the ſmall ones with the points forwards, and the ſmall porcupines at the ſame time move with the points of their teeth backwards. It was before ſtated, that the porcupines move with the points forwards when they take the wool from the feeding-rollers, but this wool is applied on the upper ſide of the porcupines, and the great porcupine is at the lower ſide; hence the direction of the teeth is reverſe in the two caſes, and occaſions the wool to be given to the great porcupine, a ſmall quantity at a time, from each of the ſmall porcupines, as they paſs over it. The great porcupine being turned ſlowly round upon its axis clothes itſelf with the wool in a continued fleece, and this is drawn off from its teeth by a pair of fluted rollers, between which it paſſes in a continued ſliver or band; this band is alſo conducted through a ſhort tube, which revolves round its axis, and rolls up the ſliver, to make it adhere better together in a round and compact form.

The action of this machine is not to comb the wool, but to divide the maſs of raw wool, which is ſpread on the feeding-cloth, into a great number of ſmall and equal portions by the ſucceſſive ſtrokes of the ſmall porcupines; theſe portions are again mixed together in one film of wool upon the great porcupine, from which the wool is drawn off in a continued ſliver, and as much twiſt is given to it as is requiſite to make the ſliver ſufficiently compact to ſubmit it to the combing-machine.

Cartwright's Combing-Machine, or *Combing-Table*; called alſo amongſt the workmen *Big Ben*.—In *Plate* II. *fig.* 1. *Worſted Spinning*, is a horizontal plan of the machine, which exhibits nearly all its parts; we have alſo given a perſpective view in *fig.* 2. of the operative parts, as they would appear if detached from the framing which ſuſtains them. A A is a circular ring of wood, which is fixed down on the framing; B B is a ſimilar ring, which is fitted into the fixed ring, with liberty to turn round within it. The interior of this ring is furniſhed with a row of comb-teeth, with the points directed to the centre, and there are two other rows of ſhorter teeth beneath, ſo as to make three circular rows of teeth. This forms a large circular comb, called the combing-table, about five feet diameter; it is moved ſlowly round in the direction of the arrow by means of a pinion, which works into a ring of cogs, fixed in ſegments withinſide of the circular comb beneath the row of teeth, as is ſhewn in the ſection, *fig.* 3.

The wool is filled upon the teeth of the circular comb by means of two machines F and G, called crank-laſhers. Theſe ſupply the wool by laſhing or throwing the lock of wool upon the teeth of the comb, and then drawing up the wool from the comb, with a motion very ſimilar to that of the hand of the workman in filling the combs, as we have before deſcribed. The crank-laſhers repeat their ſtrokes with great rapidity; but as the comb-table is kept in continual motion, the wool which is laſhed upon the teeth by the firſt crank-laſher F is carried away, and in its courſe comes beneath the other crank-laſher G, by which more wool is filled upon the teeth, and they receive the intended portion. This wool, by the rotation of the comb-table, is then carried beneath a ſmall comb K, which works by a crank movement, but with its teeth always horizontal; they penetrate through the wool, and then riſe up ſo as to comb it. After this operation, the wool is taken off from the teeth of the comb-table between a double pair of fluted rollers N, ſituated immediately over the comb-teeth; theſe draw off the combed wool in a continued ſliver, which is conducted through another pair of plain rollers R, and falls into a tin can placed there to receive it.

This machine was not found capable of combing the raw wool, chiefly becauſe the comb-teeth are not heated, and alſo becauſe the actions of laſhing on the wool, and afterwards combing it, begin to act upon wool, at firſt with their full force, and break the fibres if they are entangled together; hence it is found beſt to comb the wool by hand once over, or for fine goods twice. The wool is thus formed into ſlivers, which are joined together, by laying them on a table, with the ends lapped over each other; and rolling them together, they will join into one long ſliver. Three of theſe ſlivers are put into tin cans *i i*, which are placed upon a circular table I, and carried upwards to the crank-laſher F or G, which are both of ſimilar conſtruction. The table I is mounted on an axis, ſo as to be capable of turning ſlowly round horizontally, in order to twiſt the three ſlivers together into one; but in the machines which we have ſeen in uſe, this movement is commonly neglected, for if the ſlivers are prepared by hand-combing, as we have before deſcribed, they will hang together without twiſting.

The ſlivers, which are carried up from the cans to the crank-laſher (ſee *fig.* 3.), firſt paſs over a roller at *e*; the axle of this roller is alſo the fixed centre of motion of a trough H, which forms one part of the crank-laſher. The ſliver of wool is conducted along the trough H, and then turns over a ſecond roller at *f*; the centre-pin of this roller is the joint, which unites the end of the trough H with a moveable frame *d d*, which has a tube *g* fixed in front for the ſliver of wool to paſs through. A little below the middle of this frame *d d* are holes through its ſides, to receive the pin of a crank *b b*, of which the central axis is ſupported in bearings ſcrewed to the frame of the machine, and it is turned round by the power of the mill. By means of a pair of bevelled wheels D and E, *fig.* 1. the cranks of the two crank-laſhers are connected together, and have a common motion, but in a direction at right angles to each other. At the lower end of each of the moving frames *d d*, a pair of fluted rollers *i* are fixed, which draw the ſliver between them. The rollers are put in motion by means of a cog-wheel *k*, fixed on the extremity of the axis of the lower roller; this is turned by a ſmall pinion, fixed at the end of an axis, which paſſes through the frame *d d*, and which at the oppoſite end has a wheel *h*, that receives motion from a pinion fixed faſt to the pin of the crank. The upper of the two fluted rollers is preſſed down againſt the lower one by ſprings, which bear on its pivots with ſufficient force to hold the wool firmly between them, and draw the ſliver forwards when they turn round.

The motions of the crank-laſher are not eaſy to be underſtood from a verbal deſcription. It muſt be recollected, that the upper end of the frame *d d* which carries the rollers, being jointed to the end of the trough H, it muſt always move in the arch of a circle, as ſhewn by the dotted lines, *fig.* 3; the centre of this arch is *e*: alſo that the middle part of the frame *d*, where the crank-pin paſſes through

it,

it, muſt deſcribe a circle when the crank revolves: in conſequence, the rollers *i*, which are at the lower end of the frame, will move in a curve, as ſhewn by the dotted lines. It is an oval or diſtorted ellipſis, with the longeſt diameter horizontal.

At the ſame time the fluted rollers circulate in this orbit, they are in continual motion on their own axis, by the communication of wheel-work before deſcribed, and they draw the ſliver of wool down the tube *g*; the end of the ſliver, which projects from below the rollers, hangs down from them in a lock, and by the motion of the crank-laſher this is thrown againſt the points of the teeth in the comb-table. At the period when the wool is thus thrown on the teeth, the rollers are moving nearly in an horizontal direction, ſo as to draw the wool in the direction of the length of the teeth, and they penetrate the wool; but as the rollers proceed in their elliptic orbit, they begin to riſe and draw the wool upwards away from the teeth in an inclined direction, as is evident by tracing the dotted courſe marked out for the rollers. By thus drawing up the wool between the teeth, a portion of the wool will be left in them; the rollers then riſe up rapidly in their oval courſe, and the wool is raiſed quite above the teeth; the rollers then move forwards to make another ſtroke, and during ſuch advance, the rollers, being in continual motion, draw forwards the ſliver of wool, and the end hangs down ready to be laſhed on the teeth of the comb next time.

The motions of the ſmall comb K muſt be next deſcribed. The whole machine receives its motion by means of a wheel or pulley *c*, *fig.* 1, upon the axis of the crank for the laſher G; D and E are the bevelled wheels by which the other crank is turned; at the extreme end of the axis C is a pinion, which turns a bevelled wheel L, and on the axis of this is a wheel turning two others M M of equal ſize; on the extremities of the axes of the wheels M M are two cranks *l l* of equal radii, which are both jointed to an iron bar *m m*, and both turning round together in the ſame direction, they cauſe the bar to move in a direction parallel to itſelf, and every part of the bar deſcribes a circle equal to the radius of the cranks. The ſmall comb K is fixed to this bar, and partakes of its motion, whereby the points of its teeth are carried horizontally into the wool contained in the teeth of the great comb, then riſe upwards and draw through the fibres, in order to comb them.

In order to remove the little comb when it becomes filled with wool, it is attached to the bar *m* by means of a comb-holder or ſocket L, which has a groove at each end to receive the little comb, and it can be mounted or withdrawn at pleaſure. This ſocket L is moveable upon a horizontal pin fixed at the end of the bar *m*, ſo that it can be turned with either end upwards; and as the little comb can be fixed at either end of the ſocket, a ſpare comb is placed in the upper groove of the ſocket, whilſt the lower groove holds the comb which is in uſe; but when this becomes filled with wool, which it has gathered from the comb-table, the ſocket L is inverted by turning it half round upon its centre-pin, and by this means the freſh comb is brought down into uſe, and the other can be taken away to clear off the wool from it. There is a ſmall bolt fixed to the pin on which the ſocket L turns, which can be ſhot into a notch when the ſocket is in a perpendicular poſition, and will then hold the ſocket faſt from turning, and keep the comb in a proper poſition for its work. In this way, the little comb can be taken away and replaced by a freſh one as often as is neceſſary, without ſtopping the machine, for the ſmall comb does not move very quick. The ſame boy who attends to change the combs, when neceſſary, alſo ſets up the wool in the great comb-teeth with a ſmall ſcraper, ſo that the ſmall comb will penetrate through it with more certainty and effect. The plane of the rows of teeth in the ſmall comb is not horizontal, or parallel to the teeth of the combing-table, but inclined thereto, ſo that thoſe teeth of the ſmall comb which firſt come into action upon the wool do not penetrate deeply into it; but as the comb-table turns round, the wool advances beneath the ſmall comb, and is operated upon thoſe teeth which go deeper, and the laſt teeth of the comb go as deep as they can, not to touch the teeth of the comb-table.

The wool is now combed, and only remains to be drawn off in a continued ſliver; this is done by the drawing-off rollers N, which are fluted iron rollers, placed horizontally over the comb-teeth, and nearly in the direction of a radius of the comb-table: they are ſupported in an iron frame, and are turned round by a pair of bevelled wheels from a vertical axis P. This axis extends the whole height of the machine, and is put in motion by means of a pair of bevelled wheels, and an oblique axis Q, which is turned by a bevelled wheel and pinion on the extreme end of the axis of the firſt crank-laſher.

The great comb receives its motion from the perpendicular axis P, which turns a large wheel T by a pinion on the lower end of it: on the upper end of the axis of this wheel is the pinion which works in the ring of teeth withinſide of the comb-table: in this way, a very ſlow motion is given to the comb-table. There are two pair of drawing-off rollers N, ſituated cloſe together, and parallel to each other; the firſt pair are put in motion as we have deſcribed, and the back pair are turned by means of equal cog-wheels, ſo that they move with the ſame velocity.

The wool upon the comb-table is gathered in the hand, to form a ſliver, and the end is introduced between the rollers, which continually draw off the wool as the comb-table turns round. After paſſing through both pairs of rollers, the ſliver is conducted through a forked iron, then through a round wooden tube, and is at laſt delivered by two plain wooden rollers R into a tin can placed beneath to receive it. Theſe rollers are alſo turned by bevelled wheels on the perpendicular axis P. The drawing-off rollers only take away the long wool, the fibres of which are long enough to reach to the rollers. The two rollers compoſing the front pair of drawing-off rollers are not placed immediately over each other, but the upper roller overhangs the lower one, ſo that the plane in which the axes of the upper and lower rollers are both ſituated is inclined at about an angle of 45 degrees to the plane of the comb-table: by this means, the wool is drawn off from the comb, at an angle of 45 degrees, to paſs between the rollers.

The noils, *i. e.* the ſhort wool and broken fibres, which will not reach the drawing-off rollers, remain in the teeth of the comb-table, and alſo as much of the long wool as is on the lower ſide of the comb, and theſe are called backings: both are taken off by a boy, who is ſeated for that purpoſe within the circle of the comb-table; he firſt draws off the backings from beneath the comb, and then, with one hand above the teeth, and the other below, he draws off the noils.

Theſe two ſorts of wool are handed to a boy on the outſide of the machine, who puts them into ſeparate boxes. The backings are filled on the ſmall combs before they are put into the machine, and become ſomewhat combed by the action of the ſmall comb: when the ſmall combs are removed from the machine, the wool upon them is further combed by hand, and then drawn off from them in a continued ſliver, by means of an additional piece of machinery, which is at the ſide of the machine.

This

This combing-machine is found to break the fibre of the wool, and it increaſes the quantity of noil very much, unleſs the wool is previouſly combed once or twice by hand; and as it then becomes only a ſubſtitute for the ſecond or third combing, it ſaves little or no expence. The advantage of the machine is found, in the great regularity and equality of the ſliver which is produced by it, a circumſtance of particular importance for fine ſpinning. In combing by hand when the ſliver is drawn off, thoſe fibres which the comber firſt takes hold of are longer than the others; then as the ſliver continues to be drawn, ſhorter fibres are found in it, and the ſhorteſt are laſt of all. Theſe are called the long and ſhort ends of the ſliver; the ſhort end is always marked by twiſting or rolling it up, in order that when the ſlivers are joined together into one for ſpinning, the long and ſhort ends may be equally intermixed and diſperſed throughout the whole length. In drawing off the wool from the combing-machine, the long and ſhort fibres are intermixed and taken up together, ſo that the ſliver is of very equal texture.

There have been ſeveral other attempts to make combing-machines which deſerve notice, though they have not come into uſe.

Meſſrs. Wright and Hawkſley had a patent in 1793 for a combing-machine; and Mr. Toplis of Cuckney had alſo a patent of the ſame date, which contains ſome good ideas. Mr. Hawkſley, in 1797, had a patent for improvements on Cartwright's: the principal one was, to make the combing-table by the combination of a number of ſmall combs, which could readily be applied to the table, or detached at pleaſure. If this would allow the combs to be heated, as the inventor propoſed, they would work much better.

Mr. Amatt had a patent in 1795, and Mr. Pearce in 1798: after this time, Mr. Cartwright's machines had received ſome improvements from Mr. Hawkſley, and came into uſe; and we find leſs ſpeculation on the ſubject.

Gilpin's Combing-Machine.—In 1811, Mr. George Gilpin of Sheffield perfected a very ingenious machine, which combed the raw wool in a moſt complete manner. We do not hear that this machine is yet come into uſe, although we have no doubt of its anſwering the purpoſe, having frequently examined it while at work: its only fault was a complication of parts, which might be eaſily removed.

The outline of this machine is taken from that of Mr. Toplis in 1793, but is very much improved and perfected. *Fig.* 4. of *Plate* I. *Worſted*, is a ſketch of the principal parts. The machine works with eight combs at once, which are of rather larger ſize than the ordinary hand-combs, the rows of teeth being twenty inches long. Theſe combs are fixed upon two reels or frames A, B, which revolve upon their axles by the power of the mill; four combs, D and E, are fixed upon each reel, and in ſuch poſition that both ends of the comb-teeth, *viz.* the points and roots, are equally diſtant from the centre of the reel to which they are fixed; and the reels, with the combs fixed upon them, form two revolving wheels or frames. The combs D and E are ſo made, that they can be detached from the reels, or replaced and fixed faſt in a moment, by the attendants; and they can, therefore, be heated in a ſtove, in the ſame manner as the hand-combs. The wool is alſo filled upon the combs by hand, and the combs and wool are heated in the uſual manner before they are put into the machine, in order to comb the wool.

One of theſe reels A is ſimply turned upon its axis, but the other reel B has a curious compound motion given to it by the machinery: thus it revolves on its own axis; but the axis alſo advances to, and recedes from, the other reel with a motion parallel to itſelf, which is repeated four times in every revolution. Whilſt B advances towards A, it moves with only one-third of the velocity with which it returns from A. The advancing movement is of a limited and conſtant extent; but at the ſame time, there is a third movement which regulates this extent, ſo that at every ſucceeding ſtroke which the machine makes, the two reels will approach nearer together.

Suppoſe all the combs filled with wool, and mounted in their places upon the reels, the machine is then put in motion, and the two reels A and B turning round in oppoſite directions, their combs D and E meet each other; and by the compound movement of B, (*viz.* advancing ſlowly towards A, and turning round at the ſame time,) the combs D and E approach in ſuch a manner, that the points of each comb penetrate the wool which is in the other comb, and this is reciprocal of both combs. When the teeth are thus entered into the wool, the moveable reel B retreats quickly from the other, and the teeth, by drawing through the wool, comb and ſeparate its fibres.

The circular motion of both reels is not regular and equable, but is communicated by means of elliptical cog-wheels, which occaſion the reels to move round very ſlowly, at the moment when the comb of the reel B is drawing out or combing the wool; but this motion being finiſhed, the reels begin to turn round more rapidly, and at the ſame time the reel B approaches towards A with a ſlow movement, in order to preſent another pair of combs to each other, which meet; and each one penetrates the wool which is upon the other, and then the reel B draws out to comb it, in the manner before deſcribed.

In this way they continue to make ſucceſſive ſtrokes, until the wool is ſufficiently combed: the machine is then ſtopped, and the combs taken off one by one, to be replaced by others, which are filled with freſh wool, and properly heated.

There is likewiſe another movement of the reel A, which we have not yet mentioned: the axis of that reel has a ſlow motion backwards and forwards, endways in the direction of its length, for a ſhort diſtance. The intention of this is, that the ſame parts of the combs ſhall never come oppoſite to each other at two ſucceſſive ſtrokes.

It ſhould be obſerved, that when the machine is firſt ſet to work, the combs at their point of meeting do not come within three or four inches of each other, and the points only penetrate amongſt the longeſt fibres of the wool upon the combs; but at every ſtroke which is made, the combs advance nearer together, and take deeper into the wool, until, after a certain number of ſtrokes are made, the combs approach as near as they can without touching. They continue to work in this manner for ſome time, and when the intended number of ſtrokes is made, a bell rings as an indication that the machine ſhould be ſtopped. This is done by drawing a lever, and in conſequence the machine will ſtop itſelf in the exact poſition for changing one of the combs on each reel. Theſe are removed, and others ready filled with wool and heated are put on in their places, which being done on both reels at the ſame time by two perſons, is only the work of a moment. The machine is then put in motion again, but by the machinery it will ſtop itſelf again at the required poſition for changing the next pair of combs; it is then put forwards, and ſo on, until all the eight combs are changed.

The combs which are removed from the machine are put into the ſtove to heat for a few moments, and then the wool is drawn off from them by a ſeparate machine. The head of the comb is here placed in a perp dicular groove, ſo that its teeth ſtand horizontal; and a piece of

of metal, which is fixed to the head of the comb, and projects therefrom like a tooth, enters into the ſpiral groove of a ſcrew, which ſtands in a perpendicular poſition, and is continually turned round by the machinery. By this means, the comb is regularly and ſlowly let down in the groove, from top to bottom. A pair of fluted rollers is placed horizontally, and parallel to the teeth of the comb, in ſuch a poſition that the comb, in deſcending, will paſs with its teeth at a proper diſtance from them, to draw off the wool in a ſliver. After paſſing through theſe fluted rollers, the ſliver is conducted through a perpendicular revolving tube, which gives a roundneſs to it, the ſame as it would acquire by being rolled between the hands, and then it is conducted between a pair of plain rollers, which deliver it into a tin can placed before the machine.

A wooden roller is placed above the fluted rollers, with eight pieces of board projecting from it in the direction of radii. When the roller turns round, theſe boards act to ſtroke the wool upon the comb, and raiſe it into a proper ſituation to be drawn off by the fluted rollers.

The combs are prepared for drawing off the wool, by heating them as before mentioned, and by ſliding the wool from the roots of the teeth half way towards their points. In this ſtate, the combs are carried one by one to the drawing-off machine, and the head of one comb is put into the top of the perpendicular groove: it will be prevented from falling down in the groove by the projecting tooth, which enters the ſpiral groove of the perpendicular ſcrew. The wool is gathered up and introduced between the fluted rollers; the machine is then put in motion, and by means of the ſcrew the comb is gradually lowered down, and the wool is drawn off from it in a ſliver, which is rolled up into a compact form by the revolving tube, through which it paſſes, and is delivered into the can by the plain rollers.

The attendant holds another comb ready to follow the firſt, and when the firſt has deſcended to a certain point, he ſlips the next comb into the perpendicular groove, ſo that it reſts upon the former, and the wool upon the two combs joins as it were in one. The ſtroker, when they paſs before it, lays the fibres all one way, and the wool is drawn off by the rollers in a continued ſliver, which does not preſent the ſlighteſt appearance of joinings. Another comb is then put in, and the wool joins to the former, and ſo on. The backings, or wool at the back of the comb, are drawn off by the boy ſtationed behind the machine; and the combs, as they come through below, are received by boys, who afterwards take away the noil or ſhort wool which remains in the teeth, and then put the combs back into the ſtove to heat them, ready to be filled again, in order to proceed with another combing. When the wool of all the eight combs is drawn off, the motion of the drawing-off machine is ſtopped at the moment when the eighth or laſt comb has deſcended half way through its courſe. In this ſtate, the machine waits till another combing is finiſhed, and then the ſucceeding comb being placed on the top of that one which continues in the machine, the continuity of the ſliver will be preſerved.

The inventor of this machine ſtates in his ſpecification, that for common work the wool only requires to be operated upon once by the combing-machine; and in that caſe, the machine muſt be adapted to make twenty-four ſtrokes of each pair of combs before the bell rings. For medium work, ſuch as would require to be combed twice over, in the uſual manner of hand-combing, it muſt be combed twice over by the machine: thus, after having been combed once in the manner before deſcribed, the ſliver of wool is broken up into handfuls, and filled on the combs again by hand as before, and combed over again in a ſimilar manner; but the combs are leſs heated for the ſecond time of combing. By changing a wheel, the machine ſhould be adapted to make only fourteen or ſixteen ſtrokes before it ſtops, when it is intended to comb twice over. The wool intended for the fineſt ſpinning ſhould be combed three times over, and the machine ſhould be ſet to make fourteen or ſixteen ſtrokes of each pair of combs.

The machine has alſo two different movements for the drawing out of the moveable comb-reel: in one, the motion is over a ſpace of ten inches, and is adapted to comb ſuch wool as is ſix or eight inches length of ſtaple, and is called wether wool; but by a ſlight alteration, the excurſion of the moveable reel can be increaſed to thirteen inches, and is then adapted to comb hey wool, or wool which is from eight to eleven inches length of ſtaple.

Mr. Gilpin's machine has the advantages of heating the combs and of filling them by hand, both of which are eſſential to any machine which is propoſed to comb the raw wool. The filling is an operation which requires diſcretion, if it is expected that the long fibres ſhall be preſerved without breaking. The perſon who fills the wool on the teeth takes a greater or leſs lock of wool in his hand, according to the condition of it, and the degree of entanglement: alſo in drawing it between the comb-teeth, the force is proportioned to what the wool will bear. Mr. Gilpin's ſpecification ſtates, that under certain circumſtances, when the wool will not waſh well, but remains taggy, it is adviſeable to fill it upon the combs, and ſlip it off; then fill it again, preparatory for the machine. As the object of this firſt filling is chiefly to warm the wool, the end may be in part attained by laying the wool upon the top of the ſtove for a few minutes before it is filled.

Planking.—Let us ſuppoſe that the wool is combed either by the hand, or by the machine, and we will proceed to explain the means of preparing it into a thread. The combing-machines reduce the wool into a continued ſliver, which is ready for the drawing-frame; but the ſhort ſlivers produced by the hand-combing muſt be firſt joined together by what is called planking. Theſe ſlivers are rolled up by the combers, ten or twelve together, in balls called tops, each of which weighs half a pound: at the ſpinning-mill theſe are unrolled, and the ſlivers are laid on a long plank or trough, with the ends lapping over, in order to ſplice the long end of one ſliver into the ſhort end of another. The diſtinction of the two ends of the ſliver has been before explained; the long end being that which was firſt drawn off from the comb, and contains the longeſt fibres of the wool; the ſhort end is that which came laſt from the comb, and contains the ſhort fibres. The wool-comber lays all the ſlivers of each ball the ſame way, and marks the long end of each by twiſting up the end of the ſliver. It is a curious circumſtance, that when a top or ball of ſlivers is unrolled and ſtretched out ſtraight, they will not ſeparate from each other without tearing and breaking, if the ſeparation is begun at the ſhort ends, but if they are firſt parted at the long ends they will readily ſeparate.

Breaking-Frame.—Here the ſlivers are planked or ſpliced together, the long end of one to the ſhort end of another; they are immediately drawn out and extended by the rollers of the breaking-frame. A ſketch of this machine is given in *Plate* II. *fig.* 5; it conſiſts of four pairs of rollers, A, B, C, D. The firſt pair A receives the wool from the inclined trough E, which is the planking-table. The ſlivers are unrolled, parted, and hung looſely over a pin, in reach of the attendant, who takes a ſliver and lays it flat in the trough, and the end is preſented to the rollers A, which being in

motion

motion will draw the wool in; the ſliver is then conducted through the other rollers, as ſhewn in the figure: when the ſliver has paſſed half through, the end of another ſliver is placed upon the middle of the firſt, and they paſs through together; when this ſecond is paſſed half through, the end of a third is applied upon the middle of it, and in this way the ſhort ſlivers produced by the combing are joined into one regular and even ſliver.

The lower roller C receives its motion from the mill, by means of a pulley upon the end of its axis, and an endleſs ſtrap. The roller which is immediately over it is borne down by a heavy weight *e*, ſuſpended from hooks, which paſs over the pivots of the upper roller. The fourth pair of rollers D moves with the ſame velocity as C, being turned by means of a ſmall wheel upon the end of the axis of the roller C, which turns a wheel of the ſame ſize upon the axis of the roller D, by means of an intermediate wheel *d*, which makes both rollers turn the ſame way round. The firſt and ſecond pairs of rollers, A and B, move only one-third as quick as C and D, in order to draw out the ſliver between B and C to three times the length it was when put on the planking-table. The ſlow motion of the rollers A is given by a large wheel *a*, fixed upon the axis of the roller A, and turned by the intermediate cog-wheels *b*, *c*, and *d*; the latter communicates between the rollers C and D. The pinions on the rollers C and D being only one-third the ſize of the wheel *a*, C and D turn three times as faſt as A, for *b*, *c*, and *d*, are only intermediate wheels. The rollers B turn at the ſame rate as A. The upper roller *c* is loaded with a heavy weight, ſimilar to the rollers A; but the other rollers, B and D, are no farther loaded than the weight of the rollers.

The two pairs of rollers A B and C D are mounted in ſeparate frames, and that frame which contains the third and fourth pairs, C D, ſlides upon the caſt-iron frame F, which ſupports the machine, in order to increaſe or diminiſh the diſtance between the rollers B and C. There is a ſcrew *f*, by which the frame of the rollers is moved, ſo as to adjuſt the machine according to the length of the fibre of the wool. The ſpace between B and C ſhould be rather more than the length of the fibres of the wool. The intermediate wheels *b* and *c* are ſupported upon pieces of iron, which are moveable on centres: the centre for the piece which ſupports the wheel *b* is concentric with the axis of the roller A; and the ſupporting piece for the wheel *c* is fitted on the centre of the wheel *d*. By moving theſe pieces, the intermediate wheels *b* and *c* can be always kept in contact, although the diſtance between the rollers is varied at times. By means of this breaking-frame, the perpetual ſliver which is made up by planking the ſlivers together is equalized, and drawn out three times in length, and delivered into the can G.

Drawing-Frame.—Three of theſe cans are removed to the drawing-frame, which is ſimilar to the breaking-frame, except that there is no planking-table E. There are five ſets of rollers, all fixed upon one common frame F, the breaking-frame which we have deſcribed being the firſt. As faſt as the ſliver comes through one ſet of rollers, it is received into a can, and then three of theſe cans are put together, and paſſed again through another ſet of rollers. In the whole, the wool muſt paſs through the breaker and four drawing-frames before the roving is begun. The draught being uſually four times at each operation of drawing, and three times in the breaking, the whole will be $3 \times 4 \times 4 \times 4 \times 4 = 768$; but to ſuit different ſorts of wool, the three laſt drawing-frames are capable of making a greater draught, even to five times, by changing the pinions; accordingly the draught will be $3 \times 4 \times 5 \times 5 \times 5 = 1500$ times.

The ſize of the ſliver is diminiſhed by theſe repeated drawings, becauſe only three ſlivers are put together, and they are drawn out four times; ſo that in the whole, the ſliver is reduced to a fourth or a ninth of its original bulk.

The breaking-frame and drawing-frame, which are uſed when the ſlivers are prepared by the combing-machines, are differently conſtructed; they have no planking-table, but receive three of the perpetual ſlivers of the combing-machine from as many tin cans, and draws them out from ten to twelve times. In this caſe, all the four rollers contribute to the operation of drawing: thus the ſecond rollers B move $2\frac{1}{3}$ times as faſt as the rollers A; the third rollers C move 8 times as faſt as A; and the fourth rollers E move $10\frac{1}{2}$ times as faſt as A. In this caſe, the motion is given to the different rollers by means of bevelled wheels, and a horizontal axis, which extends acroſs the ends of all the four rollers, to communicate motion from one pair of rollers to another.

There are three of theſe ſyſtems of rollers, which are all mounted on the ſame frame; and the firſt one, through which the wool paſſes, is called the breaking-frame, but it does not differ from the others, which are called drawing-frames. The ſlivers which have paſſed through one ſyſtem of rollers are collected four or five together, and put through the drawing-rollers. In all, the ſlivers paſs through three drawings, and the whole extenſion is ſeldom leſs than 1000 times, and for ſome kinds of wool much greater.

After the drawing of the ſlivers is finiſhed, a pound weight is taken, and is meaſured by means of a cylinder, in order to aſcertain if the drawing has been properly conducted; if the ſliver does not prove of the length propoſed, according to the ſize of worſted which is intended to be ſpun, the pinions of ſome of the drawing-frames are changed, to make the draught more or leſs, until it is found by experiment that one pound of the ſliver meaſures the required length.

Roving-Frame.—This is provided with rollers the ſame as the drawing-frames: it takes in one or two ſlivers together, and draws them out four times. By this extenſion, the ſliver becomes ſo ſmall, that it would break with the ſlighteſt force, and it is therefore neceſſary to give ſome twiſt; this is done by a ſpindle and flyer. (See *fig.* 6.) A B are the two pairs of rollers, between which the ſliver is paſſed; the firſt rollers A turn round ſlowly, but the others B revolve four times as quick, to draw the ſliver to four times its original length; and as faſt as it iſſues from the roller, it is twiſted by the motion of the ſpindle C, and wound up upon the bobbin *a*. The ſpindle C is put in motion by a whip-cord band, which paſſes round the pulley *c*, and alſo round the wheel D. This wheel is fixed on a vertical axis *e*, which has a pinion on the upper end, to give motion to the lower roller B, by means of a bevelled wheel upon the end of its axis. The oppoſite end of the axis has alſo a bevelled pinion upon it, to give motion to a bevelled wheel fixed upon an horizontal axis, which carries another bevelled pinion, to give motion to a bevelled wheel fixed upon the end of the axis of the back rollers A. The ſizes of theſe wheels and pinions are ſo proportioned, that the back rollers A turn only once to every four turns of the front rollers B, as before mentioned.

The back rollers are capable of being ſet at a greater or leſs diſtance from the front rollers, according to the length of the fibres of the wool, and in all caſes the diſtance ſhould be rather more than the length of the fibres, but not a great deal.

The ſpindle is ſupported on its point, and ſuſtained by a collar at the middle of its length. Upon the top of the ſpindle, the flyer *e* is ſcrewed; it has two branches, which turn downward, and one of them has an eye at the lower end, through which the roving is conducted, in order to lay it upon the bobbin *a*. This bobbin is fitted looſely upon the upper part of the ſpindle, and reſts with its weight upon a piece of wood projecting from the bobbin-rail *f*. The rail is made to riſe and fall continually with a ſlow motion, ſo as to preſent every part of the bobbin in ſucceſſion to the eye of the flyer, and thereby wind the roving upon every part of the length of the bobbin. The bobbin is not fixed upon the ſpindle, but is fitted looſely thereupon; and by reſting upon the piece of wood which is fixed to the bobbin-rail, there is ſo much friction and reſiſtance to the motion of the bobbin, that it gathers up the roving by winding it round itſelf as faſt as the rollers give it out. The twiſt given to the roving is juſt enough to make it hang together, and one turn in each inch is uſually enough. Some roving-frames are made with four pairs of rollers, and draw ten or twelve times; and in this way, it is not neceſſary for the ſliver to paſs ſo frequently through the drawing-frame.

Spinning-Frame.—This is ſo much like the roving-frame, that a ſhort deſcription will be ſufficient. The ſpindles are more delicate, and there are three pairs of rollers inſtead of two; the bobbins which are taken off from the ſpindles of the roving-frame, when they are quite full, are ſtuck upon wires at L (*fig.* 7.), and the roving which proceeds from them is conducted between the rollers. The back pair A turns round ſlowly; the middle pair turns about twice for once of the back rollers; and the front pair B makes from twelve to ſeventeen turns for one turn of the back rollers B, according to the pinions which are employed, and theſe can be changed according to the degree of extenſion which is required.

The ſpindles muſt revolve very quickly in the ſpinning-frame, in order to give the requiſite degree of twiſt to the worſted. The hardeſt twiſted worſted is called tammy-warp, and when the ſize of this worſted is ſuch as to be twenty or twenty-four hanks to the pound weight, the twiſt is about ten turns in each inch of length. The leaſt twiſt is given to the worſted for fine hoſiery, which is from eighteen to twenty-four hanks to the pound. The twiſt is from five to ſix turns *per* inch. The degree of twiſt is regulated by the ſize of the whirls or pulleys upon the ſpindle, and by the wheel-work, which communicates the motion to the front rollers from the band-wheel, which turns the ſpindles.

It is needleſs to enter more minutely into the deſcription of the ſpinning machinery for worſted, becauſe the conſtruction is very ſimilar to the water-frame for ſpinning cotton, invented by ſir Richard Arkwright, and which is fully deſcribed in our article *Manufacture of* Cotton. The differences between the two are chiefly in the diſtance between the rollers, which in the worſted-frame is capable of being increaſed or diminiſhed at pleaſure, according to the length of the fibres of the wool, and the draught or extenſion of the roving is far greater than in the cotton.

Reeling.—The bobbins of the ſpinning-frame are placed in a row upon wires before a long horizontal reel, and the threads from 20 bobbins are wound off together. The reel is exactly a yard in circumference, and when it has wound off 80 turns, it rings a bell; the motion of the reel is then ſtopped, and a thread is paſſed round the 80 turns or folds which each thread has made: the reeling is then continued till another 80 yards is wound off, which is alſo ſeparated by interweaving the ſame thread; each of theſe ſeparate parcels is called a ley, and when ſeven ſuch leys are reeled, it is called a hank, which contains 560 yards. When this quantity is reeled off, the ends of the binding thread are tied together, to bind each hank faſt, and one of the rails of the reel is ſtruck to looſen the hanks, and they are drawn off at the end of the reel. Theſe hanks are next hung upon a hook, and twiſted up hard by a ſtick, then doubled, and the two parts twiſted together, to make a firm bundle. In this ſtate, the hanks are weighed by a ſmall index-machine, which denotes what number of the hanks will weigh a pound, and they are ſorted accordingly into different parcels. It is by this means that the number of the worſted is aſcertained as the denomination for its fineneſs: thus No. 24. means that 24 hanks, each containing 560 yards, will weigh a pound, and ſo on.

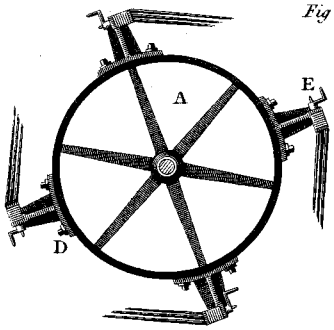
This denomination is different from that uſed for cotton, becauſe the hank of cotton contains 840 yards inſtead of 560; but in ſome places, the worſted hank is made of the ſame length as the cotton.

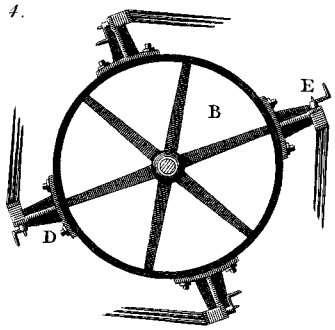
To pack up the worſted for market, the proper number of hanks are collected to make a pound, according to the number which has been aſcertained; theſe are weighed as a proof of the correctneſs of the ſorting, then tied up in bundles of one pound each, and four of theſe bundles are again tied together. Then 60 ſuch bundles are packed up in a ſheet, making a bale of 240 pounds, ready for market.

From this account of the proceſſes of worſted ſpinning, it will be ſeen that they are very ſimilar to thoſe of cotton-ſpinning, after the firſt preparation of the wool by combing inſtead of carding.

WORSTED MANUFACTURE.

Fig. 4.





BREAKING Frame.

Fig. 2.

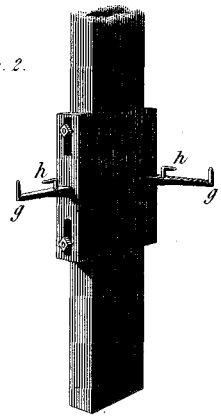


Fig. 3.

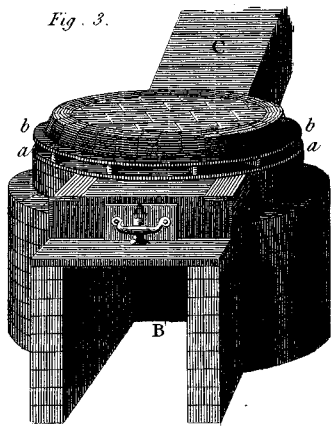


Fig. 5.

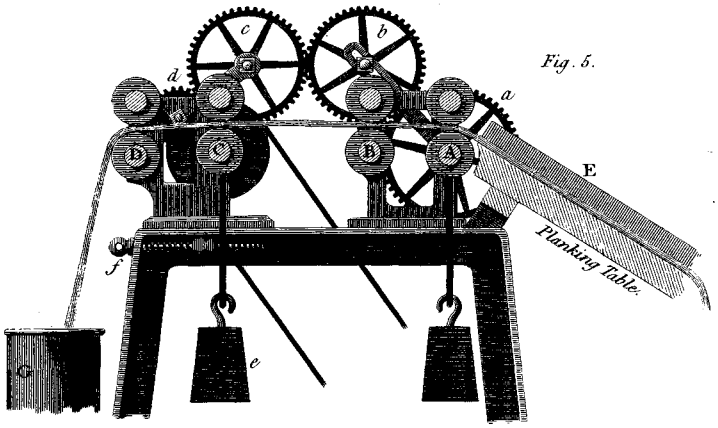
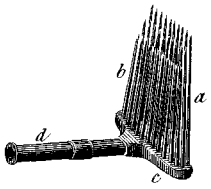
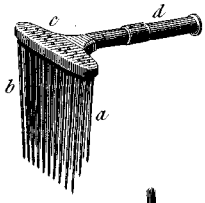
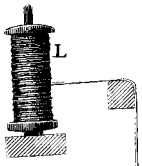


Fig. 1.







SPINNING Frame.

Fig. 7.

ROVING Frame.

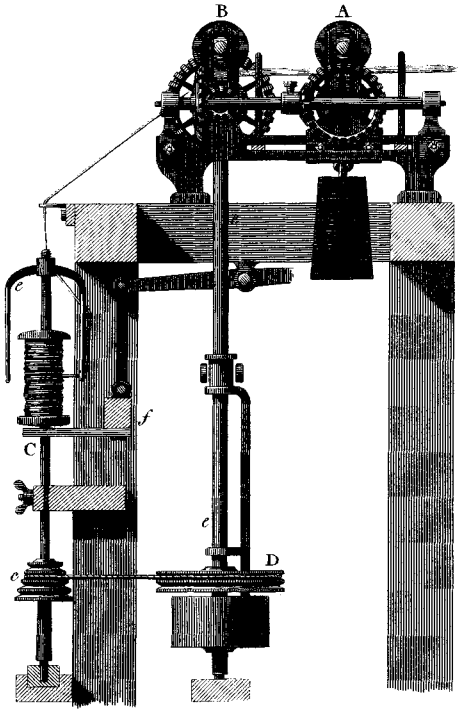
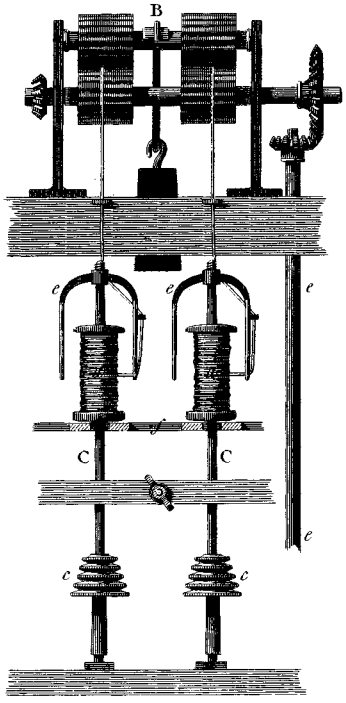
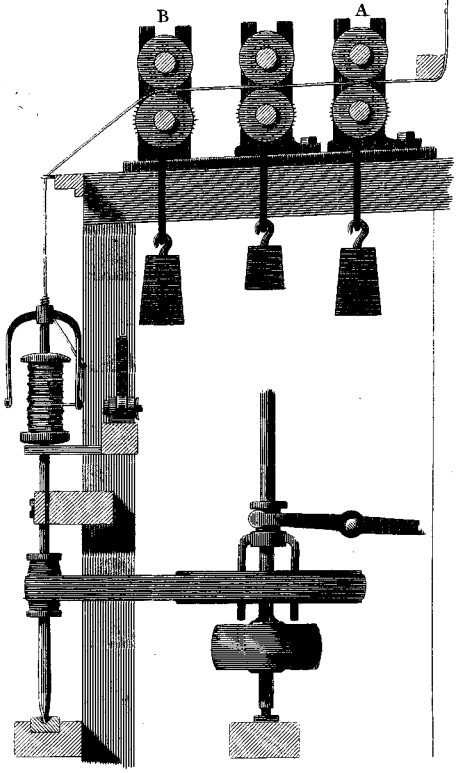


Fig. 6.

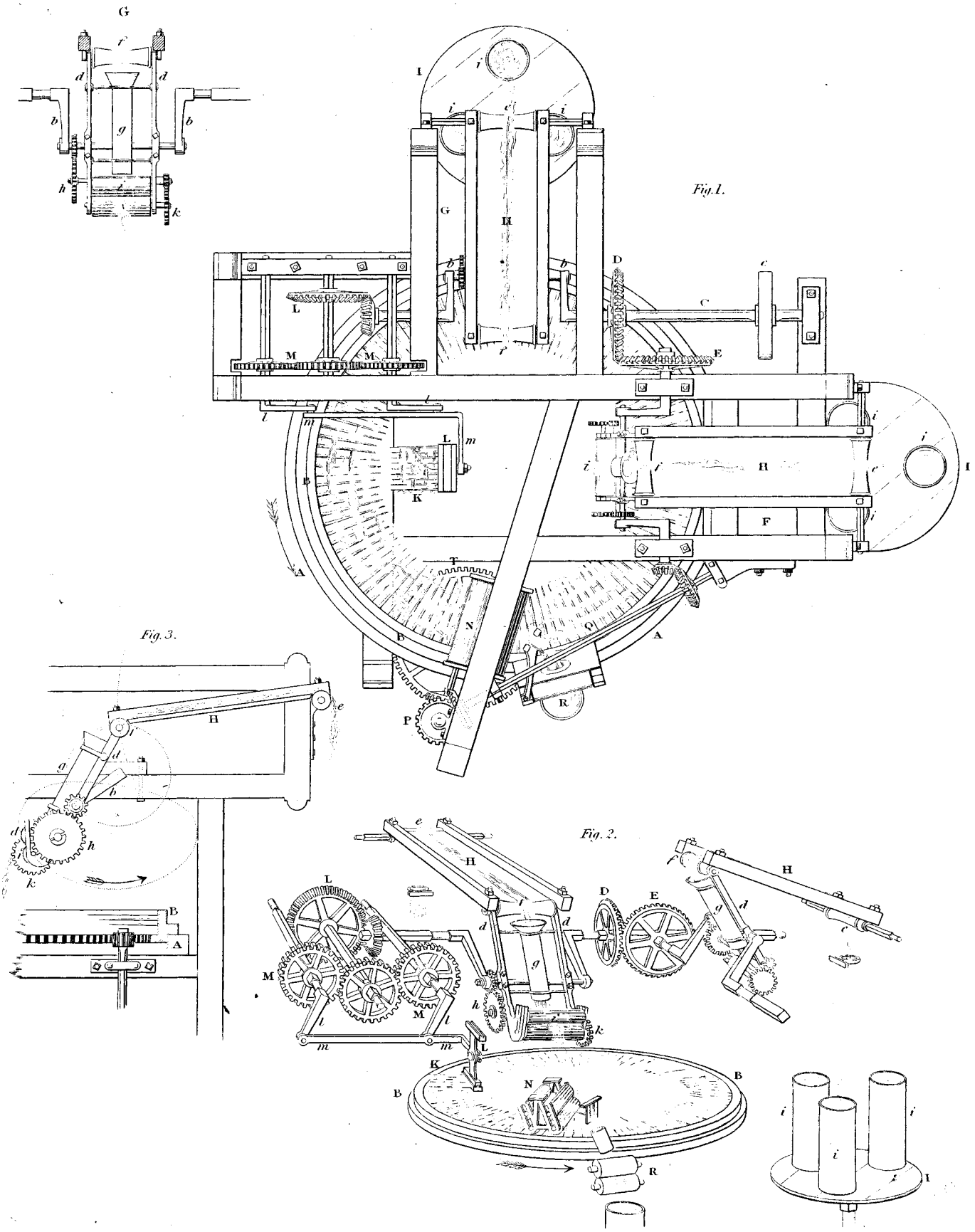




J. Farey, del. Published as the Act directs, 1819, by Longman, Hurst, Rees, Orme & Brown, Paternoster Row. W. Lowry, sc.

WORSTED MANUFACTURE.

CARTWRIGHT'S COMBING MACHINE.



J.Ewen delin.

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